

The Cell and Inheritance

Reading Preview

Key Concepts

- What role do chromosomes play in inheritance?
- What events occur during meiosis?
- What is the relationship between chromosomes and genes?

Key Term

- meiosis

Target Reading Skill

Identifying Supporting Evidence

As you read, identify the evidence that supports the hypothesis that chromosomes are important in inheritance. Write the evidence in a graphic organizer.

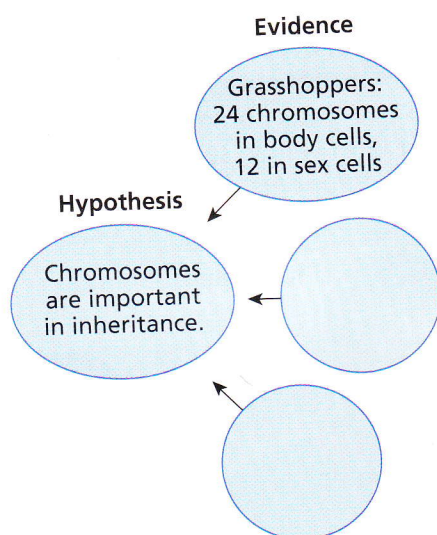


FIGURE 11
Sex Cells

The large egg is a female sex cell, and the smaller sperm is a male sex cell.

Lab
zone

Discover Activity

Which Chromosome Is Which?

Mendel did not know about chromosomes or their role in genetics. Today we know that genes are located on chromosomes.

1. Label two craft sticks with the letter A. The craft sticks represent a pair of chromosomes in the female parent. Turn the sticks face down on a piece of paper.
2. Label two more craft sticks with the letter a. These represent a pair of chromosomes in the male parent. Turn the sticks face down on another piece of paper.
3. Turn over one craft stick "chromosome" from each piece of paper. Move both sticks to a third piece of paper. These represent a pair of chromosomes in the offspring. Note the allele combination that the offspring received.

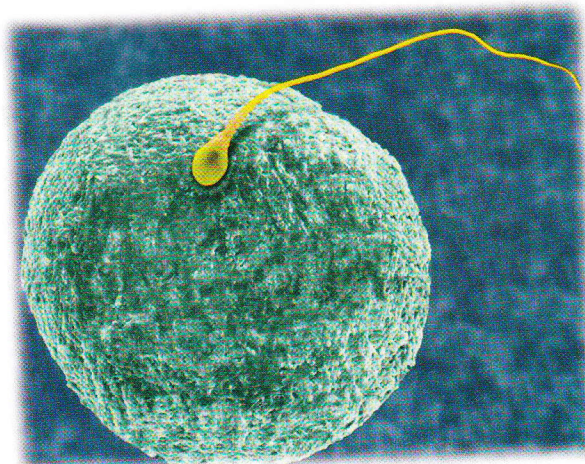
Think It Over

Making Models Use this model to explain how chromosomes are involved in the inheritance of alleles.

Mendel's work showed that genes exist. But scientists in the early twentieth century did not know what structures in cells contained genes. The search for the answer to this puzzle was something like a mystery story. The story could be called "The Clue in the Grasshopper's Cells."

In 1903, Walter Sutton, an American geneticist, was studying the cells of grasshoppers. He wanted to understand how sex cells (sperm and egg) form. Sutton focused on the movement of chromosomes during the formation of sex cells. He hypothesized that chromosomes were the key to understanding how offspring have traits similar to those of their parents.

Egg ►



◀ Sperm

Grasshopper
chromosomes ▼

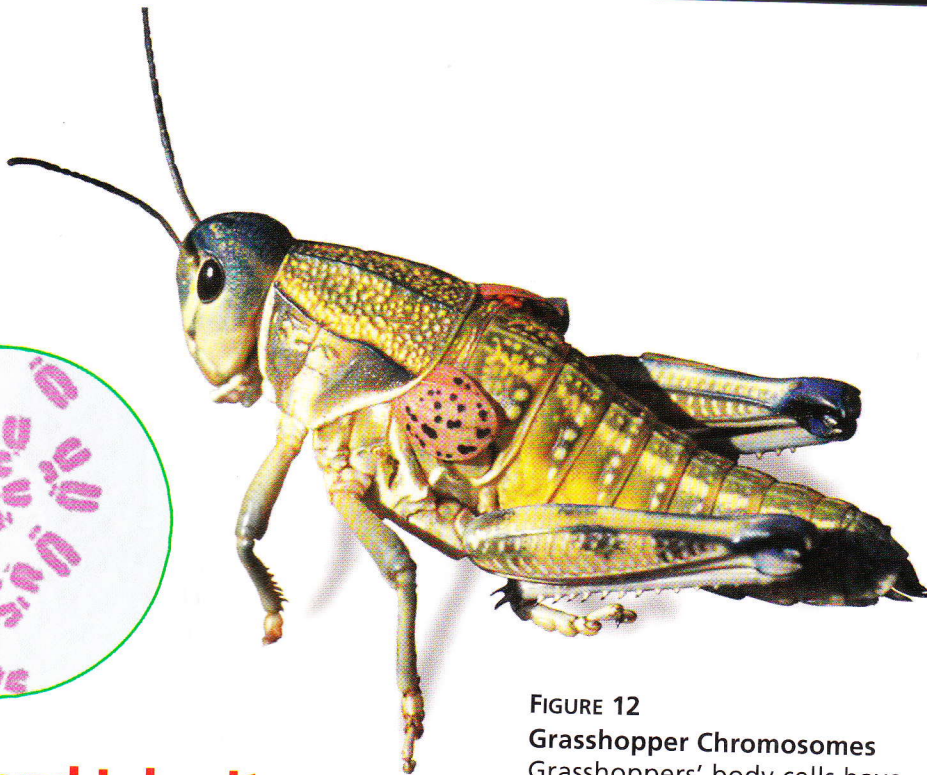
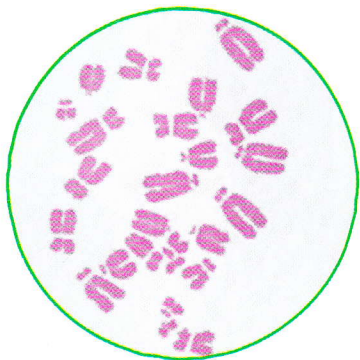


FIGURE 12

Grasshopper Chromosomes

Grasshoppers' body cells have twice the number of chromosomes as their sex cells.

Applying Concepts What is the function of chromosomes?

Chromosomes and Inheritance

Sutton needed evidence to support his hypothesis that chromosomes were important in the inheritance of traits. He found that evidence in grasshoppers' cells. The body cells of a grasshopper have 24 chromosomes. To his surprise, Sutton found that the grasshopper's sex cells have only 12 chromosomes. In other words, a grasshopper's sex cells have exactly half the number of chromosomes found in its body cells.

Chromosome Pairs Sutton observed what happened when a sperm cell and an egg cell joined during fertilization. The fertilized egg that formed had 24 chromosomes. As a result, the grasshopper offspring had exactly the same number of chromosomes in its cells as did each of its parents. The 24 chromosomes existed in 12 pairs. One chromosome in each pair came from the male parent, while the other chromosome came from the female parent.

Genes on Chromosomes Recall that alleles are different forms of a gene. Because of Mendel's work, Sutton knew that alleles exist in pairs in an organism. One allele in a pair comes from the organism's female parent and the other allele comes from the male parent. Sutton realized that paired alleles were carried on paired chromosomes. Sutton's idea came to be known as the chromosome theory of inheritance. **According to the chromosome theory of inheritance, genes are carried from parents to their offspring on chromosomes.**

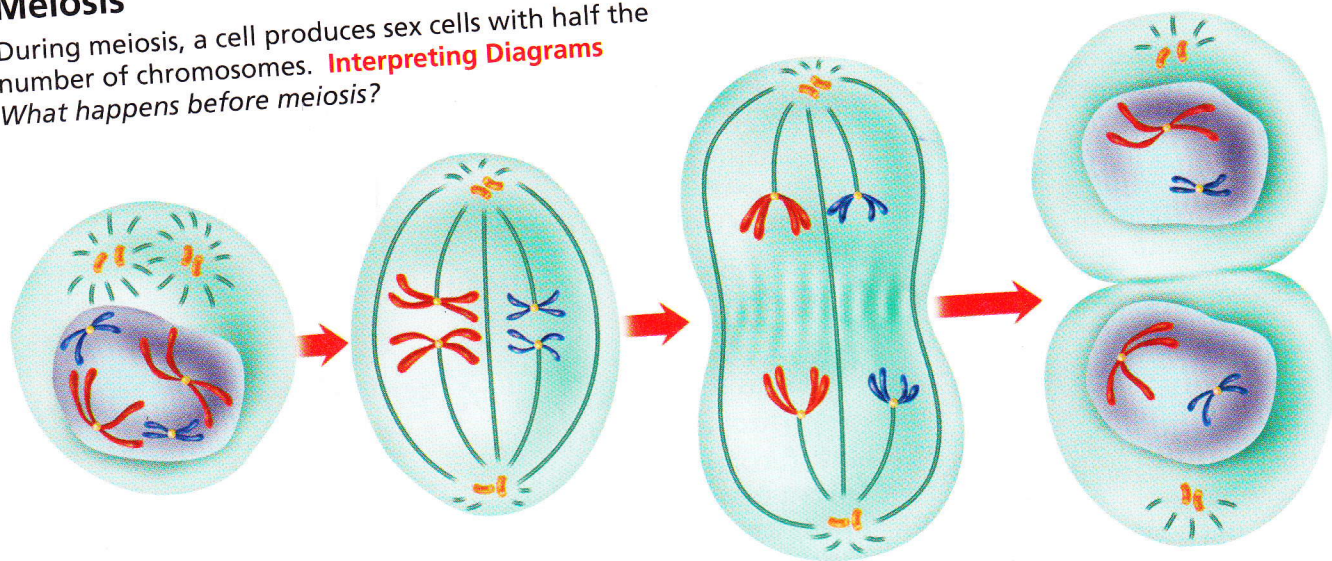


**Reading
Checkpoint**

What is the relationship between alleles and chromosomes?

FIGURE 13 Meiosis

During meiosis, a cell produces sex cells with half the number of chromosomes. **Interpreting Diagrams**
What happens before meiosis?



1 Before Meiosis

Before meiosis begins, every chromosome in the parent cell is copied. Centromeres hold the two chromatids together.

2 Meiosis I

A The chromosome pairs line up in the center of the cell.

B The pairs separate and move to opposite ends of the cell.

C Two cells form, each with half the number of chromosomes. Each chromosome still has two chromatids.

Meiosis

How do sex cells end up with half the number of chromosomes as body cells? To answer this question, you need to understand the events that occur during meiosis. **Meiosis** (my OH sis) is the process by which the number of chromosomes is reduced by half to form sex cells—sperm and eggs.

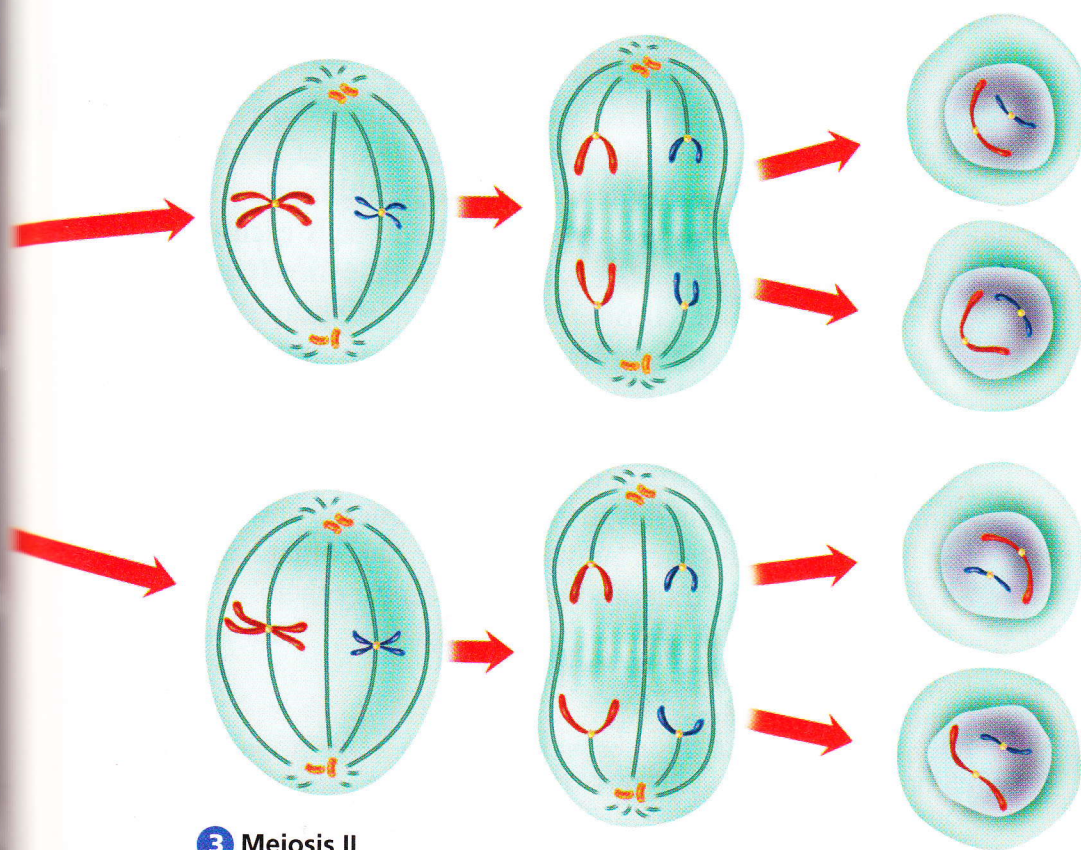
What Happens During Meiosis You can trace the events of meiosis in Figure 13. In this example, each parent cell has four chromosomes arranged in two pairs. **During meiosis**, the chromosome pairs separate and are distributed to two different cells. The resulting sex cells have only half as many chromosomes as the other cells in the organism. The sex cells end up with only two chromosomes each—half the number found in the parent cell. Each sex cell has one chromosome from each original pair.

When sex cells combine to form an organism, each sex cell contributes half the normal number of chromosomes. Thus, the offspring gets the normal number of chromosomes—half from each parent.

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3 Meiosis II

A The chromosomes with their two chromatids move to the center of the cell.

B The centromeres split, and the chromatids separate. Single chromosomes move to opposite ends of the cell.

4 End of Meiosis

Four sex cells have been produced. Each cell has only half the number of chromosomes that the parent cell had at the beginning of meiosis. Each cell has only one chromosome from each original pair.

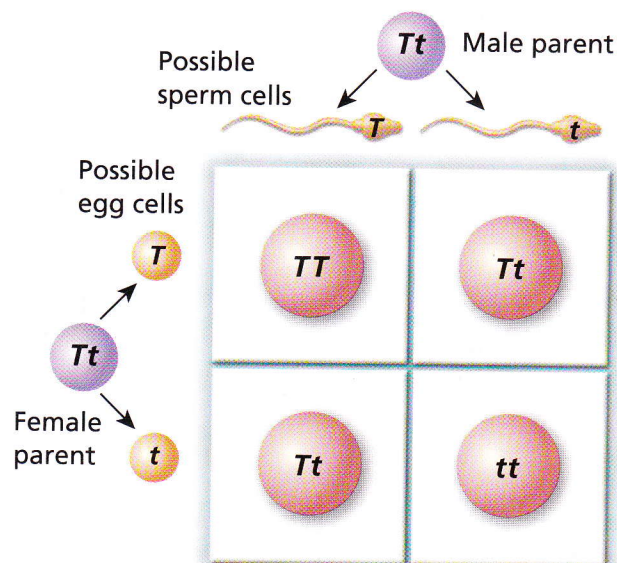
Meiosis and Punnett Squares A Punnett square is actually a way to show the events that occur at meiosis. When the chromosome pairs separate and go into two different sex cells, so do the alleles carried on each chromosome. One allele from each pair goes to each sex cell.

In Figure 14, you can see how the Punnett square accounts for the separation of alleles during meiosis. As shown across the top of the Punnett square, half of the sperm cells from the male parent will receive the chromosome with the *T* allele. The other half of the sperm cells will receive the chromosome with the *t* allele. In this example, the same is true for the egg cells from the female parent, as shown down the left side of the Punnett square. Depending on which sperm cell combines with which egg cell, one of the allele combinations shown in the boxes will result.

FIGURE 14

Meiosis Punnett Square

Both parents are heterozygous for the trait of stem height. The Punnett square shows the possible allele combinations after fertilization.





A Lineup of Genes

The body cells of humans contain 23 chromosome pairs, or 46 chromosomes. **Chromosomes are made up of many genes joined together like beads on a string.** Although you have only 23 pairs of chromosomes, your body cells each contain between 20,000 and 25,000 genes. Each gene controls a trait.

In Figure 15, one chromosome in the pair came from the female parent. The other chromosome came from the male parent. Notice that each chromosome in the pair has the same genes. The genes are lined up in the same order on both chromosomes. However, the alleles for some of the genes might be different. For example, the organism has the A allele on one chromosome and the a allele on the other. As you can see, this organism is heterozygous for some traits and homozygous for others.

FIGURE 15
Genes on Chromosomes

Genes are located on chromosomes. The chromosomes in a pair may have different alleles for some genes and the same alleles for others.

Classifying For which genes is this organism homozygous? For which genes is it heterozygous?

Section 3 Assessment

Target Reading Skill Identifying Supporting Evidence Refer to your graphic organizer about the chromosome theory of inheritance as you answer Question 1 below.

Reviewing Key Concepts

1. a. **Comparing and Contrasting** According to Sutton's observations, how does the number of chromosomes in a grasshopper's body cells compare to the number in its sex cells?
- b. **Describing** Describe what happens to the number of chromosomes when two grasshopper sex cells join in fertilization.
- c. **Explaining** How do Sutton's observations about chromosome number support the chromosome theory of inheritance?
2. a. **Defining** What is meiosis?
- b. **Interpreting Diagrams** Briefly describe meiosis I and meiosis II. Refer to Figure 13.
- c. **Sequencing** Use the events of meiosis to explain why a sex cell normally does not receive both chromosomes from a pair.

3. a. **Describing** How are genes arranged on a chromosome?
- b. **Comparing and Contrasting** How does the order of genes in one member of a chromosome pair compare to the order of genes on the other chromosome?

Writing in Science

Newspaper Interview You are a newspaper reporter in the early 1900s. You want to interview Walter Sutton about his work with chromosomes. Write three questions you would like to ask Sutton. Then, for each question, write answers that Sutton might have given.